# COTTON

## Relationships between Insufficient Potassium and Crop Maturity in Cotton

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### ABSTRACT

**Potassium deficiency in cotton (*Gossypium hirsutum* L.) depresses yield by decreasing late season growth and is reportedly more harmful to early maturing cotton genotypes. Research objectives were to determine if the accelerated maturity caused by K deficiency was partially caused by earlier flowering and to further evaluate whether early maturity cotton genotypes are more susceptible to low K levels. Field studies were conducted from 1995 to 1997 utilizing two okra-normal leaf-type near isoline pairs and two K fertilization rates (0 and 112 kg K ha$^{-1}$). Okra leaf-type genotypes are earlier in maturity than their normal leaf-type counterparts. White bloom counts, dry matter partitioning, light interception, lint yield, yield components, and fiber quality data were collected. Genotypes responded similarly to K rates for all of the parameters evaluated. Early season flowering rates briefly increased 11% when plants were grown without supplemental K. Late-season leaf area index (LAI) was 23% lower without supplemental K compared with plants fertilized with 112 kg K ha$^{-1}$ in 2 of the 3 yr. The increased LAI of the K-fertilized plants allowed them to intercept 6% more of the late season sunlight than the 0 kg K ha$^{-1}$ treatment. Potassium fertilization increased yield 9% in 2 out of 3 yr, but low K had only minor effects on fiber quality. Early maturing okra-leaf cotton genotypes are not more susceptible to low K rates because of their early maturity. The low K effect on crop maturity is due to a premature termination of reproductive growth and a brief enhancement of the early season flowering rate.**

Optimum cotton (*Gossypium hirsutum* L.) yields are dependent on the availability of an adequate K supply throughout the growing season. Despite the considerable research conducted on cotton K fertility over the past 15 yr, questions and misconceptions still exist concerning the effects that adequate and deficient K levels have on cotton growth and development, yield, and fiber quality.

One of the prevailing assumptions regarding K deficiency in cotton is that fast-fruiting, earlier maturing genotypes are more susceptible to K deficiency than the more full-season genotypes (Tupper et al., 1996; Oosterhuis, 1999). Supposedly, the compaction of reproductive growth into a shorter time frame with high yielding, early maturing genotypes intensifies the K demand and need during this period. This assumption persists even though one study found no differences in the response to K among cotton genotypes of varying maturities (Pettigrew et al., 1996). The varying genetic makeups of the genotypes used by Pettigrew et al. (1996) and in other studies complicate the issue and make it difficult to prove cause and effect for maturity differences being responsible for any variation in response among genotypes to K. Theoretically, differences in root system size or effectiveness could be identified as genotypic differences in response to different K fertility levels. Differences in cotton root surface areas have been linked to differences in K uptake and yield response to K fertility (Cassman et al., 1989; Brouder and Cassman, 1990).

Okra leaf-type cotton lines often are earlier in maturity and produce more flowers than their normal leaf-type near isogenic counterparts (Heitholt et al., 1993; Heitholt, 1995). By utilizing okra leaf and normal leaf-type near isogenic pairs, one should be able to narrow the genetic variation and provide a more direct comparison of whether earlier maturity leads to enhanced susceptibility to K deficiencies. The leaf-type genetic variation would still exist, but most of the other genetic variation would be minimized.

Another characteristic commonly associated with cotton grown under low K conditions is that the crop can be harvested earlier than comparable plants grown under adequate soil K (Bennett et al., 1965; Gwathmey and Howard, 1998; Pettigrew, 1999). The prevailing assumption is that the crop runs out of K, causing an early termination of the reproductive growth and reducing overall lint yields. While Kerby and Adams (1985) suggested that high soil K levels did not delay early boll set, little if any research has addressed whether low K promotes earlier initiation of reproductive growth. Earlier flowering and the resulting boll load may also contribute to the earlier harvest observed with K-deficient plants. Other stresses have sometimes, but not always, been able to accelerate the initiation of reproductive growth in cotton (Guinn and Mauney, 1984). The plant hormone ethylene is often produced by plants in response to various stresses (Lieberman, 1979). Artificial products, such as ethephon [(2-chloroethyl)phosphonic acid], that degrade into ethylene once inside the plant cells, have been reported to induce flowering in certain plant species (de Wilde, 1971).

An improved understanding of K nutrition in cotton would help producers better manage their inputs for optimal yield and fiber quality. Therefore, the objectives of this research were: (i) to conduct a more direct test of whether the early maturing trait leads to an increased sensitivity to low K levels for cotton and (ii) to determine whether low K levels hasten crop maturity of cotton through both an early initiation of flowering and an early termination of reproductive growth.

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Published in Agron. J. 95:1323–1329 (2003).


**Abbreviations:** DAP, days after planting; LAI, leaf area index; PPFD, photosynthetic photon flux density; SLW, specific leaf weight.

## MATERIALS AND METHODS

During 1995–1997, field studies were conducted on a Beulah fine sandy loam (coarse-loamy, mixed, thermic Typic Dystrochrepts) near Stoneville, MS. In 1995, three cotton genotypes ('MD 51 ne normal leaf-type', 'MD 51 ne okra leaf-type', and 'Stv. 6413 okra leaf-type') were grown. Genotypes MD 51 ne normal and MD 51 ne okra are near isogenic lines of one another, with the okra leaf-type trait being backcrossed six generations into the normal leaf-type parent line. In 1996 and 1997, 'Stv. 6413 normal leaftype' was grown, in addition to the three genotypes grown in 1995. Genotype Stv. 6413 okra was produced by backcrossing the okra leaf-type trait four generations into the Stv. 6413 normal leaf-type parent line. The okra leaf-type lines were generously supplied by W.R. Meredith, Jr. In addition to the leaf-type variation, the normal leaf-type genotypes tend to be later in maturity than their okra leaf-type near isogenic counterparts. Each year half the plots received 112 kg K ha$^{-1}$ as KCl applied preplant incorporated, whereas the remaining plots received no K fertilization (0 kg K ha$^{-1}$). The 0 kg K ha$^{-1}$ plots were situated on areas that had not received K fertilization for multiple years and were therefore low in soil K levels (Pettigrew et al., 1996). Experimental units were plots comprised of six rows, spaced 1 m apart, and 6.1 m in length. All plots were planted on 2 May 1995, 27 Apr. 1996, and 18 Apr. 1997. Plots were initially overseeded and then hand-thinned to a population density of 97 000 plants ha$^{-1}$ at the first or second true leaf stage. The experimental design was a randomized complete block consisting of eight replicates and a split plot treatment arrangement. Main plots were the K fertility rates and subplots were the genotypes.

Preplant soil samples were collected from a 0- to 15-cm depth and a 15- to 30-cm depth in all K fertility main plots during each year of the study. Samples were analyzed for K by Pettiet Soil Testing and Plant Analyses Lab., Leland, MS. The samples were extracted using the Mehlich 3 soil extract methodology (Mehlich, 1984) and elements determined using an inducely coupled argon plasma emission spectrophotometer.

The percentage of photosynthetic photon flux density (PPFD) intercepted by the canopies was determined with a LI 190SB point quantum sensor (LiCor, Lincoln, NE)[1] positioned above the cotton canopy and a 1 m long LI 191SB line quantum sensor placed on the ground perpendicular to and centered on the row. Two measurements were collected per plot, with the average of those measurements used for later statistical analysis. Canopy PPFD interception data was collected on 50, 69, 83, and 98 d after planting (DAP) in 1995. In 1996 the data were collected on 52, 75, 86, and 100 DAP, and in 1997 on 68, 81, 94, and 108 DAP.

One of the inner plot rows was designated for dry matter harvests. On each harvest date, the aboveground portions of plants from 0.3 m of row were harvested and separated into leaves, stems and petioles, and squares and bolls. Leaf area index (LAI) was determined by passing the leaves through a LI-3100 leaf area meter (LiCor, Lincoln, NE), and main stem nodes were counted. Samples were dried for at least 48 h at 70°C, and dry weights determined. Dry matter harvests were taken on 55, 78, 92, and 112 DAP in 1995. In 1996, dry matter data was collected on 45, 59, 81, 95, and 114 DAP. In 1997, dry matter harvests were taken on 52, 74, 89, 103, and 117 DAP. Growth analysis (Brown, 1984) was conducted on the various dry matter components each year.

White blooms (blooms at anthesis) produced per unit ground area were determined by counting the number of white blooms produced in a single plot row on a weekly basis to document the blooming rate throughout the growing seasons. These counts were initiated at the first sign of blooming and continued until bloom production had virtually ceased each year.

A 4.6-m inside section of one of the inner plot rows, previously designated as the harvest row, was hand-harvested multiple times to determine yield. Plots were harvested on 120, 134, 148, and 162 DAP in 1995. In 1996, the yield harvests occurred on 129, 143, and 156 DAP. The harvests, in 1997, were on 144, 157, 171, and 185 DAP. The seed cotton was ginned to determine lint yield and lint percentage. Boll mass was determined by dividing the seed cotton weight by the number of bolls harvested. Average seed mass was determined from 100 nondelinted seeds per plot. Fiber quality analyses were determined by Starlab (Knoxville, TN). Fiber bundle strength and fiber elongation were determined with a stelometer. Span lengths were measured with a digital fibrograph. Fiber maturity, wall thickness, and perimeter were calculated from arealometer measurements.

The data were statistically analyzed using analysis of variance. A separate analysis was conducted each year for the various data gathered because the number of genotypes tested differed among the years. When genotype × K rate interactions were not significant or meaningful, genotypes means were averaged across K rates, and K rate means were averaged across genotypes. Genotype and K rate means were separated using a protected LSD at $P \leq 0.05$.

## RESULTS AND DISCUSSION

Preseason soil K concentrations at depths of both 0 to 15 cm and 15 to 30 cm were on average about 25% higher with 112 kg K ha$^{-1}$ than without K fertilization (Table 1). Soil K levels <127 mg kg$^{-1}$ are considered deficient for cotton production on this soil type in Mississippi. Potassium deficiency symptoms became visually obvious in plots of the 0 kg K ha$^{-1}$ treatment by late August of each year. This K deficiency was due to the low initial soil K levels and the lack of added K fertilizer during this study (Pettigrew et al., 1996).

The fast-flowering, early maturing characteristics of

**Table 1. Preplant soil K concentration at two soil depths from plots that received annual applications of 0 or 112 kg ha$^{-1}$ K in 1995 to 1997.**

| K fertilization | Soil K conc. sample depth 0–15 cm | 15–30 cm |
|---|---|---|
| | mg kg$^{-1}$ | |
| | 1995 | |
| 0 kg K ha$^{-1}$ | 159 | 159 |
| 112 kg K ha$^{-1}$ | 218 | 192 |
| LSD (0.05) | 11 | 26 |
| | 1996 | |
| 0 kg K ha$^{-1}$ | 157 | 148 |
| 112 kg K ha$^{-1}$ | 214 | 194 |
| LSD (0.05) | 14 | 22 |
| | 1997 | |
| 0 kg K ha$^{-1}$ | 138 | 116 |
| 112 kg K ha$^{-1}$ | 198 | 151 |
| LSD (0.05) | 14 | 7 |

[1] Trade names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product or service, and the use of the name by USDA implies no approval of the product or service to the exclusion of others that may also be suitable.

the okra leaf-type isolines utilized in this study are classically demonstrated in Fig. 1. During the first half of the growing season for each of the 3 yr constituting this study, the okra leaf-type lines produced more flowers than their normal leaf-type counterparts. Late in the seasons both leaf-types experienced a cessation of flowering brought about by the lack of sufficient assimilates to support continued vegetative growth, otherwise known as *cutout*. These flowering rates are similar to those reported earlier using other okra-normal leaf-type isoline pairs (Heitholt, 1995). This early maturing of the okra leaf-type lines also manifest itself as a higher percentage of the total yield being picked on the first hand harvest (Table 2). Even though the okra leaf-type lines produced more flowers, their higher rate of flower abortion (Heitholt and Schmidt, 1994; Heitholt, 1995) prevent them from having greater yields than their normal leaf counterparts.

Despite being earlier in maturity, the okra leaf-type lines did not respond any differently to the two different rates of K fertilization than did their normal leaf-type parent lines for lint yield ($P > F$ for the genotype $\times$ K fertilization interaction = 0.15 in 1995, 0.96 in 1996, and 0.19 in 1997). Because there were also no significant genotype $\times$ K fertilization interactions for any of the other traits (data not shown), the K fertilization treatment means were averaged across genotypes and the genotype means were averaged across K fertility treatments.

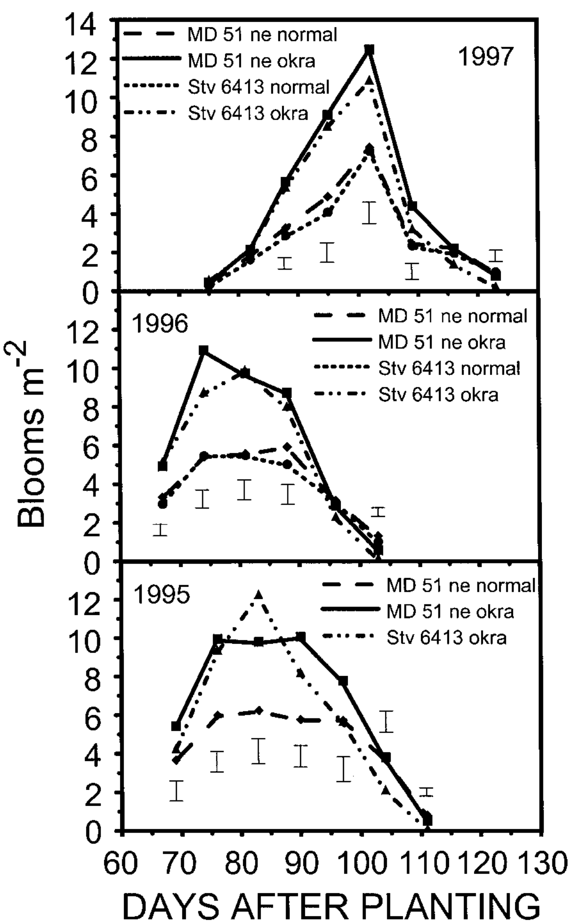


**Fig. 1. White blooms (blooms at anthesis) m$^{-2}$ of ground area at various times throughout the 1995 to 1997 growing seasons in plots of the cotton genotypes MD 51 ne normal leaftype, MD 51 ne okra leaftype, Stv. 6413 normal leaftype, and Stv. 6413 okra leaftype. The genotype means were averaged across two K fertility treatments. Vertical bars denote LSD values at the 0.05 level and are present only when the differences between genotypes are statistically significant at the 0.05 level.**

Dry matter harvests on various dates during the years demonstrated slight differences between the K rates (Table 3). No K rate differences were detected in either plant height or the number of main stem nodes for any of the harvest dates. These lack of differences in height or main stem nodes contrasts with earlier work finding that low soil K reduced the cutout plant height and node number (Pettigrew and Meredith, 1997). Low soil K level reduced leaf area index (LAI) late in the growing season in 2 out of the 3 yr in the study. The LAI at the cutout dry matter harvest (92 DAP in 1995 and 95 DAP in 1996) averaged 23% less in the plants from 0 kg K ha$^{-1}$ treatment compared with the plants receiving 112 kg K ha$^{-1}$. Specific leaf weight (SLW) exhibited the most consistent K rate differences of any vegetative growth parameter measured. Increased SLWs with the 0 kg K ha$^{-1}$ treatment were detected on 8 of the 14 sample dates during the 3 yr. These LAI and SLW responses to K fertility were similar to those reported previously (Pettigrew and Meredith, 1997; Pettigrew, 1999). In general, total aboveground plant dry weight was unaffected by K rate. However, the 112 kg K ha$^{-1}$ rate produced greater plant dry matter at 95 and 114 DAP in 1996. Harvest index was not consistently affected by the K rate for any year of the study. Growth analysis did not detect any K fertility differences in crop growth rate, relative growth rate, or net assimilation rate for any growth period within any of the 3 yr (data not shown).

Canopy PPFD interception was significantly affected by K fertilization and closely followed the LAI differences detected between the K rates (Fig. 2). Plants receiving K fertilization intercepted more solar radiation

**Table 2. Lint yield and yield component response of four genotypes averaged across K fertility levels for the years 1995 to 1997.**

| Genotype | Lint yield | % 1st harvest | Boll no. | Boll mass | Lint % |
|---|---|---|---|---|---|
| | kg ha$^{-1}$ | % | bolls m$^{-2}$ | g | % |
| | | 1995 | | | |
| MD 51 ne normal | 913 | 45 | 61 | 4.20 | 35.6 |
| MD 51 ne okra | 879 | 58 | 61 | 4.02 | 36.0 |
| Stv 6413 okra | 827 | 62 | 60 | 3.80 | 36.1 |
| LSD (0.05) | 52 | 5 | ns | 0.15 | ns |
| | | 1996 | | | |
| MD 51 ne normal | 1256 | 64 | 83 | 4.01 | 37.8 |
| MD 51 ne okra | 1102 | 84 | 80 | 3.57 | 38.7 |
| Stv 6413 normal | 1142 | 62 | 75 | 4.13 | 36.8 |
| Stv 6413 okra | 1132 | 81 | 78 | 3.65 | 39.6 |
| LSD (0.05) | 58 | 4 | 4 | 0.09 | 0.6 |
| | | 1997 | | | |
| MD 51 ne normal | 1308 | 62 | 76 | 4.33 | 39.5 |
| MD 51 ne okra | 1212 | 71 | 75 | 4.10 | 39.3 |
| Stv 6413 normal | 1259 | 55 | 74 | 4.41 | 38.8 |
| Stv 6413 okra | 1204 | 69 | 75 | 3.93 | 40.8 |
| LSD (0.05) | 86 | 4 | ns | 0.19 | 0.8 |

**Table 3. Potassium fertilization effects on dry matter partitioning averaged across genotypes at various days after planting for the years 1995 to 1997.**

| Days after planting | K fertilization | Height | Nodes | Height/node | Leaf area index | Specific leaf wt. | Total wt. | Harvest index |
|---|---|---|---|---|---|---|---|---|
| | | cm | | cm node$^{-1}$ | | g m$^{-2}$ | | |
| | | | | 1995 | | | | |
| 55 | 0 kg K ha$^{-2}$ | 70.4 | 14.0 | 5.0 | 1.66 | 68.6 | 237 | – |
| | 112 kg K ha$^{-2}$ | 70.3 | 13.9 | 5.1 | 1.72 | 64.0 | 236 | – |
| | LSD (0.05) | NS† | NS | NS | NS | 2.8 | NS | – |
| 78 | 0 kg K ha$^{-2}$ | 114.2 | 21.3 | 5.4 | 2.99 | 60.2 | 567 | 0.18 |
| | 112 kg K ha$^{-2}$ | 114.4 | 21.2 | 5.4 | 3.82 | 52.5 | 604 | 0.16 |
| | LSD (0.05) | NS | NS | NS | NS | NS | NS | NS |
| 92 | 0 kg K ha$^{-2}$ | 121.3 | 22.1 | 5.5 | 2.91 | 58.1 | 672 | 0.28 |
| | 112 kg K ha$^{-2}$ | 123.5 | 22.4 | 5.5 | 3.68 | 53.8 | 776 | 0.26 |
| | LSD (0.05) | NS | NS | NS | 0.71 | 4.3 | NS | NS |
| 112 | 0 kg K ha$^{-2}$ | 120.4 | 21.3 | 5.7 | 1.47 | 57.7 | 791 | 0.50 |
| | 112 kg K ha$^{-2}$ | 120.4 | 21.3 | 5.7 | 1.97 | 50.4 | 787 | 0.46 |
| | LSD (0.05) | NS | NS | NS | NS | NS | NS | NS |
| | | | | 1996 | | | | |
| 45 | 0 kg K ha$^{-2}$ | 49.8 | 10.9 | 4.6 | 1.07 | 62.3 | 124 | 0.01 |
| | 112 kg K ha$^{-2}$ | 47.9 | 10.8 | 4.4 | 1.20 | 57.7 | 121 | 0.01 |
| | LSD (0.05) | NS | NS | NS | NS | NS | NS | NS |
| 59 | 0 kg K ha$^{-2}$ | 91.7 | 16.0 | 5.7 | 2.32 | 62.9 | 306 | 0.03 |
| | 112 kg K ha$^{-2}$ | 93.3 | 15.7 | 6.0 | 2.53 | 55.9 | 313 | 0.04 |
| | LSD (0.05) | NS | NS | NS | NS | 5.6 | NS | 0.01 |
| 81 | 0 kg K ha$^{-2}$ | 120.5 | 20.9 | 5.8 | 3.26 | 60.3 | 617 | 0.22 |
| | 112 kg K ha$^{-2}$ | 123.1 | 20.8 | 5.9 | 3.47 | 54.5 | 621 | 0.21 |
| | LSD (0.05) | NS | NS | 0.1 | NS | 5.5 | NS | NS |
| 95 | 0 kg K ha$^{-2}$ | 118.8 | 21.1 | 5.6 | 2.31 | 64.9 | 696 | 0.39 |
| | 112 kg K ha$^{-2}$ | 124.1 | 21.3 | 5.8 | 3.08 | 56.6 | 789 | 0.36 |
| | LSD (0.05) | NS | NS | 0.2 | 0.50 | 4.6 | 90 | NS |
| 114 | 0 kg K ha$^{-2}$ | 116.9 | 20.7 | 5.7 | 1.20 | 64.5 | 745 | 0.57 |
| | 112 kg K ha$^{-2}$ | 123.5 | 21.5 | 5.8 | 1.90 | 56.9 | 865 | 0.53 |
| | LSD (0.05) | NS | NS | NS | 0.57 | 3.0 | 111 | 0.02 |
| | | | | 1997 | | | | |
| 52 | 0 kg K ha$^{-2}$ | 17.4 | 7.3 | 2.4 | 0.21 | 58.6 | 19 | – |
| | 112 kg K ha$^{-2}$ | 17.3 | 7.2 | 2.4 | 0.23 | 56.5 | 19 | – |
| | LSD (0.05) | NS | NS | NS | NS | 1.3 | NS | – |
| 74 | 0 kg K ha$^{-2}$ | 71.5 | 16.4 | 4.3 | 2.09 | 58.3 | 250 | 0.03 |
| | 112 kg K ha$^{-2}$ | 68.7 | 16.1 | 4.3 | 2.04 | 54.4 | 229 | 0.04 |
| | LSD (0.05) | NS | NS | NS | NS | NS | 20 | NS |
| 89 | 0 kg K ha$^{-2}$ | 98.8 | 20.1 | 4.9 | 3.01 | 59.7 | 497 | 0.16 |
| | 112 kg K ha$^{-2}$ | 98.2 | 19.7 | 5.0 | 3.03 | 53.5 | 441 | 0.13 |
| | LSD (0.05) | NS | NS | NS | NS | 5.8 | NS | NS |
| 103 | 0 kg K ha$^{-2}$ | 105.4 | 21.8 | 4.8 | 3.00 | 61.4 | 707 | 0.33 |
| | 112 kg K ha$^{-2}$ | 104.4 | 21.9 | 4.8 | 3.26 | 57.1 | 680 | 0.30 |
| | LSD (0.05) | NS | NS | NS | NS | NS | NS | NS |
| 117 | 0 kg K ha$^{-2}$ | 99.3 | 21.7 | 4.6 | 2.32 | 63.4 | 690 | 0.49 |
| | 112 kg K ha$^{-2}$ | 100.6 | 21.5 | 4.7 | 2.48 | 55.0 | 675 | 0.45 |
| | LSD (0.05) | NS | NS | NS | NS | NS | NS | NS |

† Not significantly different at $P \leq 0.05$.

than the plants that did not receive K fertilizer. There appeared to be a general trend for the K fertility differences to increase throughout the growing season, peaking around the period of cutout, and thereafter diminishing as leaf senescence progressed late in the season. Canopy PPFD measurements taken at approximately cutout (83 DAP in 1995, 86 DAP in 1996, and 94 DAP in 1997) averaged 6% higher in the 112 kg K ha$^{-1}$ treatment compared with the 0 kg K ha$^{-1}$ treatment. Similar K effects on cotton canopy light interception have been reported by Gwathmey and Howard (1998).

Weekly white bloom counts taken throughout each year's growing season averaged approximately 11% higher in the 0 kg K ha$^{-1}$ treatment between 70 and 80 DAP than in the 112 kg K ha$^{-1}$ treatment (Fig. 3). This enhancement of early flowering indicate that plants not receiving any K fertilizer may initiate flowering earlier than plants grown under higher K conditions. By midseason, the flowering rates of the plants receiving 112 kg K ha$^{-1}$ were either similar to (1996–1997) or had exceeded (1995) those of the plants not receiving K fertilization.

Plants receiving K fertilization yielded more than plants that did not receive any K for 2 out of the 3 yr (Table 4). The lint yield increased an average of 9% during these 2 yr, but the yield components responsible for this yield increase differed between years. In 1996, the 112 kg K ha$^{-1}$ plants produced bolls 8% heavier than the 0 kg K ha$^{-1}$ plants. This larger boll mass could be attributed to more seed boll$^{-1}$, greater seed mass, and more lint seed$^{-1}$ (lint index) found with the 112 kg K ha$^{-1}$ treatment compared with the 0 kg K ha$^{-1}$ treatment. In 1997, the production of 4% more bolls per unit of ground area was the principal yield component contributing to the yield increase observed with the 112 kg K ha$^{-1}$ treatment. In addition, the 112 kg K ha$^{-1}$ treatment had a 4% greater seed mass than the 0 kg K ha$^{-1}$ treatment in 1997. During the 2 yr that K fertilization produced the yield increase (1996 and 1997), 9% more of the total yield had been produced by the first

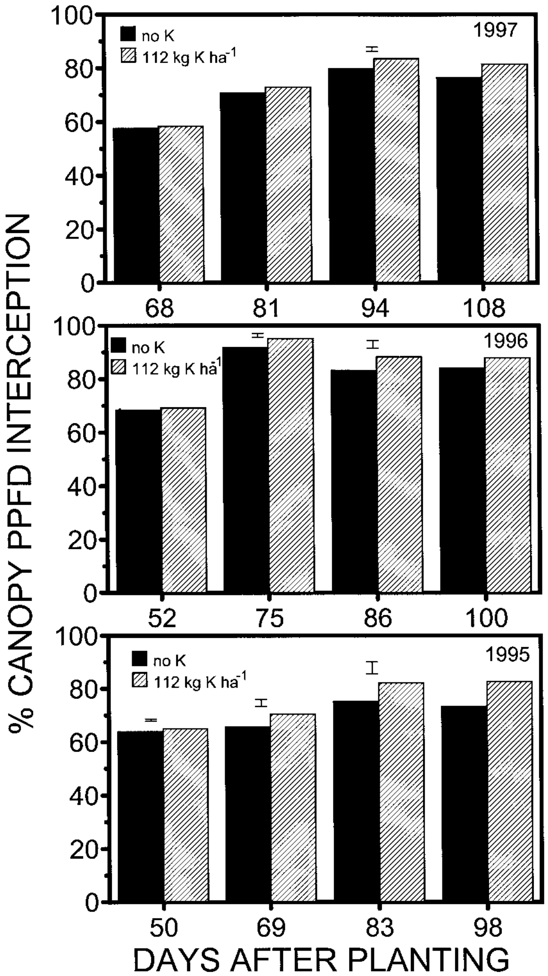


**Fig. 2. Percentage photosynthetic photon flux densities (PPFD) intercepted by cotton canopies grown with either 0 or 112 kg K ha$^{-1}$ at various times throughout the 1995 to 1997 growing seasons. The K fertility treatment means were averaged across genotypes. Vertical bars denote LSD values at the 0.05 level and are present only when the differences between K fertility treatments are statistically significant at the 0.05 level.**

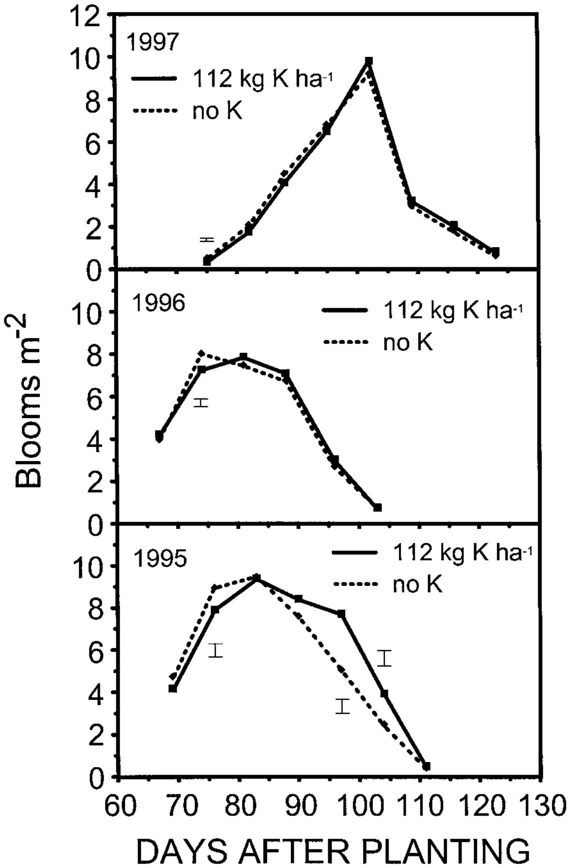


**Fig. 3. White blooms (blooms at anthesis) m$^{-2}$ of ground area at various time throughout the 1995 to 1997 growing seasons in plants grown with either 0 or 112 kg K ha$^{-1}$. The K fertility treatment means were averaged across genotypes. Vertical bars denote LSD values at the 0.05 level and are present only when the differences between K fertility treatments are statistically significant at the 0.05 level.**

harvest for the plants not receiving any K than for the 112 kg K ha$^{-1}$ plants. This increase in percentage first harvest further demonstrates the earlier maturity of the plants grown without K fertilization. The K fertilization yield increases observed in this research are similar to those reported in prior research (Pettigrew et al., 1996; Pettigrew 1999; Gwathmey and Howard, 1998; Cassman et al., 1990).

Potassium fertilization had only minor impacts on fiber quality (Table 5). For 2 out of 3 yr (1995 and 1997), the 50% span length was reduced an average of 2% when K fertilizer was withheld from the plants. Fiber elongation was also reduced an average of 6% for 2 out of the 3 yr (1996 and 1997) in the 0 kg K ha$^{-1}$ treatment. Plants grown at 0 kg K ha$^{-1}$ also produced lint with a 4% lower micronaire in 1997 and tended to be lower in the other years. No other fiber traits were altered by applying K, and the fiber quality traits reduced by low soil K were not altered to the point that they would be shifted into the price discount range.

The okra leaf-type trait promoted earlier maturity in two different genetic backgrounds (Fig. 1 and Table 2), which was similar to previous research involving okra-normal leaf-type near isoline pairs (Heitholt et al., 1993; Heitholt, 1995). Contrary to some popular assumptions, the early maturity linked to the okra leaf-type trait did not make these plants more susceptible to the damaging effects of insufficient K. None of the data collected (dry matter, flowering rate, yield or fiber quality) indicated that the okra leaf-type genotypes were more susceptible to low K levels than their normal leaf-type counterparts. This study provided a more direct comparison of any maturity influence on the response of cotton to varying levels of soil K fertility due to its minimization of the genetic variation than other K fertility studies involving multiple genotypes (Pettigrew et al., 1996; Tupper et al., 1996). The enhanced sensitivity of early maturing cotton genotypes to K deficiency reported by others (Tupper et al., 1996) was probably more related to other genetic variation among the diverse genotypes utilized rather than a maturity difference issue. Based on the work of Cassman et al. (1989) and Brouder and Cassman (1990), it would not be surprising to find that cotton genotypes with less sensitivity to low soil K levels, also had larger or more efficient root systems. Variations in

**Table 4. Potassium fertilization effects on lint yield and yield components averaged across genotypes for the years 1995 to 1997.**

| K fertilization | Lint Yield | % 1st harvest | Boll no. | Boll mass | Lint % | Lint index | Seed mass | Seed no. |
|---|---|---|---|---|---|---|---|---|
| | kg ha$^{-1}$ | % | bolls m$^{-2}$ | g | % | mg seed$^{-1}$ | mg | seed boll$^{-1}$ |
| | | | | 1995 | | | | |
| 0 kg K ha$^{-1}$ | 893 | 58 | 63 | 3.94 | 35.9 | 48 | 86 | 29.1 |
| 112 kg K ha$^{-1}$ | 853 | 52 | 58 | 4.07 | 35.8 | 49 | 88 | 29.5 |
| LSD (0.05) | NS† | NS | 4 | NS | NS | NS | NS | NS |
| | | | | 1996 | | | | |
| 0 kg K ha$^{-1}$ | 1110 | 75 | 79 | 3.70 | 38.2 | 54 | 88 | 25.8 |
| 112 kg K ha$^{-1}$ | 1207 | 70 | 79 | 3.98 | 38.3 | 57 | 91 | 26.8 |
| LSD (0.05) | 53 | 2 | NS | 0.07 | NS | 1 | 2 | 0.4 |
| | | | | 1997 | | | | |
| 0 kg K ha$^{-1}$ | 1198 | 68 | 74 | 4.11 | 39.6 | 63 | 95 | 26.0 |
| 112 kg K ha$^{-1}$ | 1293 | 61 | 77 | 4.28 | 39.5 | 65 | 99 | 26.0 |
| LSD (0.05) | 46 | 4 | 1 | NS | NS | NS | 2 | NS |

† Not significantly different at $P \leq 0.05$.

**Table 5. Potassium fertilization effects on fiber quality traits averaged across genotypes for the years 1995 to 1997.**

| K fertilization | Span length 2.5% | Span length 50% | Fiber strength | Fiber elongation | Micronaire | Fiber maturity | Fiber perimeter | Length uniformity† |
|---|---|---|---|---|---|---|---|---|
| | cm | cm | kN m kg$^{-1}$ | % | | % | μm | |
| | | | | 1995 | | | | |
| 0 kg K ha$^{-1}$ | 2.77 | 1.40 | 215 | 7.0 | 4.02 | 82 | 46.4 | 50.8 |
| 112 kg K ha$^{-1}$ | 2.79 | 1.42 | 215 | 7.2 | 4.07 | 83 | 46.3 | 50.8 |
| LSD (0.05) | NS‡ | 0.02 | NS | NS | NS | NS | NS | NS |
| | | | | 1996 | | | | |
| 0 kg K ha$^{-1}$ | 2.84 | 1.42 | 206 | 8.0 | 3.84 | 78 | 47.9 | 49.9 |
| 112 kg K ha$^{-1}$ | 2.87 | 1.42 | 205 | 8.4 | 3.96 | 80 | 48.6 | 50.1 |
| LSD (0.05) | NS | NS | NS | 0.3 | NS | NS | NS | NS |
| | | | | 1997 | | | | |
| 0 kg K ha$^{-1}$ | 2.92 | 1.42 | 214 | 7.1 | 4.28 | 89 | 44.2 | 48.8 |
| 112 kg K ha$^{-1}$ | 2.92 | 1.45 | 215 | 7.6 | 4.46 | 90 | 44.8 | 49.1 |
| LSD (0.05) | NS | 0.02 | NS | 0.2 | 0.13 | NS | NS | NS |

† Length uniformity = (50% Span length ÷ 2.5% Span length) × 100.
‡ Not significantly different at $P \leq 0.05$.

root system size and efficiency of K uptake would show more cause and effect for explaining genetic differences in response to K deficiency.

Based on this research, the earlier maturity of a cotton crop when it is grown under low K conditions is due in part to at least two components. First, the low K levels late in the growing season leads to a premature cessation of reproductive growth relative to adequately fertilized plants (Table 4). A brief accelerated early season flowering for cotton grown under low soil K levels constitutes the second component contributing to earlier maturity of a low K cotton crop (Fig. 3). This short increased early season flowering is surprising considering that Kerby and Adams (1985) reported that K fertilization did not delay boll set. However, the consistency of this phenomenon across all 3 yr of this study elevates the credibility of the finding. A stress-induced flowering response, possibly involving ethylene, may speculatively provide some rationale for the increased early flowering observed with low K plants (Guinn and Mauney, 1984; Lieberman, 1979).

In conclusion, early maturity linked to the okra leaf trait does not increase the susceptibility of cotton to low K conditions. Other variables undoubtedly cause some early maturing cotton genotypes to appear more sensitive to K deficiency. The earlier crop maturity associated with low K conditions is due both to a brief enhancement of the early season flowering rate, and also due to a premature halt to reproductive growth caused by K levels insufficient to support continued growth. Producers should take into consideration the extension of reproductive growth produced by K fertilization that allows it to achieve its superior yields when planning their management strategies.

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